

The invention in which an exclusive right is claimed is defined by the following:

1. A spring actuator, comprising:

(a) a spring comprising a ferromagnetic shape memory alloy (FSMA) composite, the FSMA composite including a ferromagnetic material and a shape memory alloy (SMA) material, the FSMA having a generally quadrilateral cross section, such that the ferromagnetic material exhibits a generally stretched X shaped cross section, with the SMA material being disposed peripherally about the generally quadrilateral cross section;

(b) a hybrid magnetic trigger, the hybrid magnetic trigger including at least one permanent magnet and at least one electromagnet; and

(c) a yoke configured to couple a magnetic flux from the hybrid magnetic trigger to the spring, such that when the hybrid magnetic trigger is energized, the spring is attracted to the yoke and contracts.

2. The spring actuator of Claim 1, wherein the yoke further comprises a plurality of fences configured to direct magnetic flux from the hybrid magnetic trigger into the spring.

3. The spring actuator of Claim 2, wherein the plurality of fences includes inner fences that are disposed within the spring and outer fences that are external relative to the spring.

4. The spring actuator of Claim 2, wherein the plurality of fences include outer fences that are external relative to the spring, but no fences disposed within the spring.

5. The spring actuator of Claim 1, wherein the ferromagnetic material comprises iron.

6. The spring actuator of Claim 1, wherein the SMA material comprises an alloy of copper, aluminum, and manganese.

7. A spring actuator, comprising:

(a) a first spring assembly including a ferromagnetic shape memory alloy (FSMA) spring and a corresponding drive unit, the drive unit including at least one permanent magnet, at least one electromagnet, and a yoke configured to direct magnetic flux into the FSMA spring; and

(b) at least one additional spring assembly, each additional spring assembly including a ferromagnetic shape memory alloy (FSMA) spring and a corresponding drive unit including at least one permanent magnet, at least one electromagnet, and a yoke configured to direct magnetic flux into the FSMA spring in the additional spring assembly, the first spring assembly and each additional spring assembly being configured in a stack.

8. The spring actuator of Claim 7, wherein the FSMA spring is formed from a homogenous FSMA material.

9. The spring actuator of Claim 8, wherein the homogenous FSMA material is an alloy comprising iron and palladium.

10. The spring actuator of Claim 7, wherein the FSMA spring is formed from a FSMA composite material.

11. The spring actuator of Claim 7, wherein each drive unit is substantially disk shaped.

12. The spring actuator of Claim 7, wherein the at least one permanent magnet in each drive unit is ring shaped.

13. The spring actuator of Claim 7, wherein the at least one electromagnet in each drive unit is disposed between two permanent magnets.

14. The spring actuator of Claim 7, wherein the yoke comprises iron and a polymer.